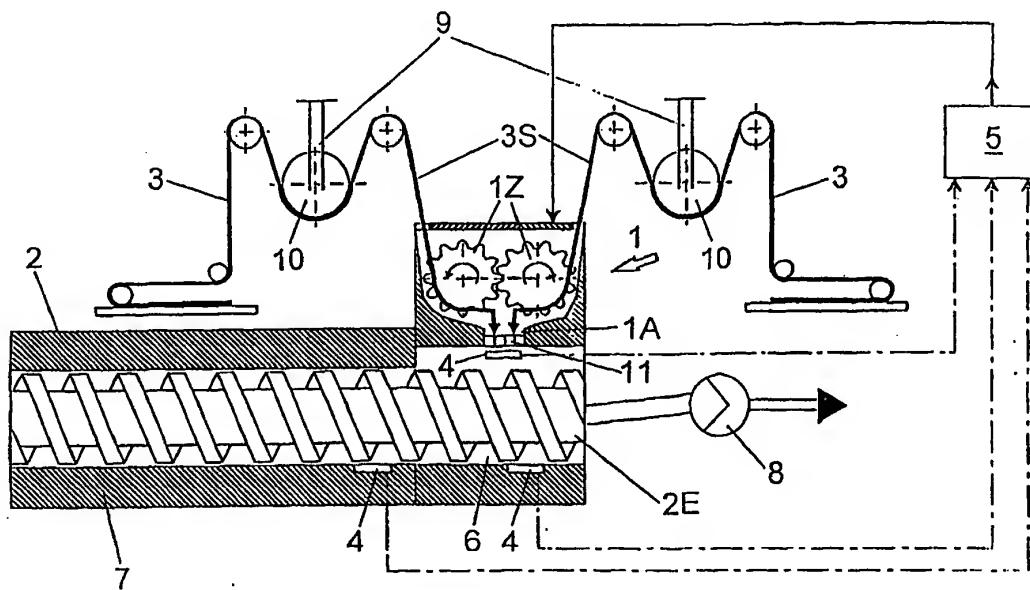


INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : B29C 47/50, 47/10, 47/76		A1	(11) International Publication Number: WO 98/09792
(21) International Application Number: PCT/EP97/04727			(43) International Publication Date: 12 March 1998 (12.03.98)
(22) International Filing Date: 30 August 1997 (30.08.97)			(81) Designated States: JP, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).
(30) Priority Data: 196 35 706.3 3 September 1996 (03.09.96) DE 60/056,090 28 August 1997 (28.08.97) US			Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
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(54) Title: **PROCESS FOR PLASTIFICATION, STRAINING, DOSING AND TRANSPORTING HIGH VISCOSITY MELTS AND DEVICE FOR CARRYING OUT THE PROCESS**



(57) Abstract

In a method for the plasticizing, filtering, dosing and transporting of high viscous polymer melts (3), for example, rubber compounds or thermoplastic resins, via a gear pump (1) and an extruder (2), the melt (3) is introduced to or drawn-in by the gear pump (1) in an unplasticized state, a plasticizing of the melt (3) is effected during transport via the teeth (1Z) of the gear pump (1), and the melt (3) is then directly transferred to the extruder (2) in a plasticized state. In a device for carrying out the method, the extruder (2) is disposed downstream of the gear pump (1).

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PROCESS FOR PLASTIFICATION, STRAINING, DOSING AND
TRANSPORTING HIGH VISCOS MELTS AND DEVICE FOR CARRYING OUT
THE PROCESS

The invention concerns a process for plastification, straining, dosing and transporting high viscous melts, for example a thermoplastic resin or a rubber compound, using a gear pump and a screw machine as well as a device for carrying out the process.

The use of gear pumps for the processing of high viscous melts is well known. Good performance of the pump can be achieved with special construction details as e. g. described in DE 413031261, EP 050828511, EP 0559582 A1, EP 0595764 A1. The use of a combination of gear pump and extruder is also well known (see e. g. EP 0513 593 A2, EP 0508 079 A2, EP 0508 080 A2).

The processing of high viscous polymers, e. g. rubber compounds or plastic resins, is associated with very special problems. In particular, compounds capable of chemical reaction at relatively low temperatures are highly demanding for the extrusion unit. To avoid an unwelcome reaction at too early a stage - e. g. the vulcanization of rubber compounds within the extrusion unit - the mean temperature within the extruder should be kept at a rather low level. Frictional heat must therefore be minimized. This means that shear stresses within the extruder should be as low as possible. A parameter strongly influencing the frictional heat is the channel depth of the extruder screw. The smaller the channel height, the higher is the amount of friction that is introduced into the material. On the other hand, the rubber melt should be plasticized and heated-up as uniformly

as possible. Only in this manner can a homogeneous product formation and good product shape be achieved.

For larger extruder sizes, conflicting goals obtain which cannot be solved by conventional machines. The screw has to be cut quite deeply in order to avoid too high an input of frictional heat. The rubber itself exhibits a so-called "yield stress", i. e., a shear stress below which the material does not flow and cannot be sheared. Since the stress is not uniform in the screw channel, zones can be established where no shear occurs at all. This problem is particularly observed in large machines (Screw Diameter 6 inches and more) or with high viscous rubber compounds having a high "green strength".

In consequence of the above mentioned effects, a non-isothermal flow field in the screw channel characterized by high temperatures at the screw ground and barrel surface and a low temperature in the center of the screw channel is observed ("cold core"). The "yield stress" responsible for this problem is quite strongly temperature dependent and decreases with increasing mass temperature.

To overcome these problems, rubber compounds can be pre-warmed at a separate device, normally an open roll mill. The material preheated in this manner - which then has a low yield stress - is fed to a so-called warm fed extruder.

Due to the high cost of this method, elimination of the pre-warming step has been a goal of high priority for all rubber processors. Special extruders which permit cold fed extrusion processing for rubber compounds have been commercially available for about 20 years. These machines

are equipped with special elements located in the barrel wall, e. g. mixing pins in the case of the pin barrel extruder, or special screws, e. g. transfer mix extruders which can facilitate homogeneous plastification of the material even for large "cold fed" machines. Although these devices are much cheaper than a combination of roll mill and "warm fed" extruders, some major disadvantages still remain. These are:

The throughput of the above mentioned cold fed extruder exhibits large variations due to the geometry of the feed strip. Therefore a separate strip processing step is necessary or variations in the geometry of the extrudate have to be accepted.

In the case of pin barrel extruders, the removal and re-installation of the screw are very time consuming. If individual pins break during operation, severe damage could result to the entire machine.

The above mentioned special screws have a very complex geometry. As a result they can only be optimized to individual applications. Thus the versatility of these machines is low. Moreover, rubber compound yield stress phenomena may lead to poor self cleaning of the screws resulting in long cleaning intervals between charge changes.

The underlying purpose of the invention is to develop a method to plasticize, strain, dose and transport high viscous melts and to develop a unit which avoids the described disadvantages of prior art.

This purpose is achieved by a process in which:

- the melt (or the cold rubber compound) is fed to a gear pump in an unplasticized form or is pulled into the gear pump via its gear wheels
- the above mentioned melt is plasticized during passage through the pump
- the melt, which has been plasticized by the gear pump is directly fed to a screw machine.

Further advantageous modifications of the process are described in claims 2 through 7. A very sensitive aspect of the handling of the plasticized melt delivered by the gear pump is the devolatilization. Since the pump teeth can never be filled completely by the feed strips, air inclusions cannot be avoided. Since, many products are sensitive thereto, such air bubbles have to be eliminated in the extruder itself. The invention describes 3 ways of doing so:

First, a vacuum pump can be used to evacuate the feed zone of a "conventional" screw, i. e. this zone operates at a low pressure.

Second, the screw can be constructed in such a manner that it has a vacuum lock. The feed zone to which the gear pump delivers the plasticized melt produces the pressure to overcome the resistance of the vacuum lock. While passing the ribbed surface of the lock, the stream of plasticized material is flattened out and air inclusions are transported to the surface. In the vacuum zone following the vacuum lock, fluent

components can be suctioned off.

Third, the gear pump itself is used to produce the pressure to overcome the vacuum lock (as shown in Figs. 3 to 5). In this manner, the feed zone of the extruder could be completely eliminated. Distribution of the compound over the circumference of the screw is effected either by a mandrel die or by a special groove in the barrel surface.

The described solution highly improves rubber extrusion since:

- the material is plasticized homogeneously without over-heated spots
- constant pressure build-up can be achieved in the unit so that variations in the cross section of the feed strip only result in minor changes in the extrudate geometry.

The device in accordance with the invention can achieve high throughputs without the disadvantages of usual "cold fed" machines. The feed strips normally used in the rubber industry could be directly drawn-in by the gear pump from beds, boxes or the like. This forced feed action causes surface effects, which are dominant in conventional extruder feed zones, to not play a significant role.

A new concept in accordance with the invention is the fact that, for the first time, the properties of the gear pump as a pre-mastication unit are used and integrated into the overall concept. The system effects further solutions to the problem of air inclusions via the gear pump. In contrast to

known processes, the gear pump is not used as a dosing unit at the tip of the screw, rather delivers a preplasticized melt to the downstream screw machine. The screw of same can be deeply cut. A large channel depth is possible without the danger of build-up of a "cold core".

A principal aspect of the invention is the fact that the gear pump directly feeds an extruder.

Further advantageous modifications are described in claims 9 through 19.

Some examples, sketched in the enclosed figures, explain the principle of the invention:

Figure 1 shows a cross section through a unit comprising a gear pump and a screw extruder

Figure 2 shows another unit in a schematic fashion

Figure 3

through

Figure 5 show solutions for melts which have to fulfill high requirements with respect to devolatilization.

The device shown in figure 1 illustrates a gear pump 1 and an extruder 2, characterized by the fact that the extruder 2 is fed by gear pump 1. The rubber 3 is initially fed in region 3S, to the gear pump or it is drawn-in by the pump 1 itself. The material is plasticized as it passes through the pump by gear wheels 1Z of pump 1. The melt 3 leaving the pump 1 is fed directly to the extruder 2.

A pressure measuring device 4 is disposed at outlet 1A of the gear pump 1 to measure the pressure directly at outlet 1A during processing. The measured values are introduced to a regulation device 5 to regulate the rate of revolution of gear pump 1. It is, however, also possible to dispose a pressure measuring device 4 at the transfer location 6 between the gear pump 1 and the extruder 2 to measure the pressure at the transfer location 6 during processing and to introduce the measured values to the regulation device 5. In an alternative variation, a pressure measuring device 4 is disposed in the first cylinder zone 7 following the feed zone to measure the pressure in the cylinder zone 7 during processing and to introduce the measured values to the regulation device 5. Since the rate of revolution of gear pump 1 is changed by regulation device 5 in dependence on a pressure signal of the extruder 2, the regulation device 5 guarantees a constant throughput of the downstream extruder 2 and smooths out feed fluctuations of short time constant, possibly caused by irregularities in the rubber strips 3S. In this manner the user has access to an additional parameter for controlling processing.

A suction device 8 is disposed at the draw-in zone 2E of the extruder 2. Alternatively, the draw-in zone 2E can be configured in such a manner that it accommodates high mass pressures. This is possible since the draw-in zone 2E does not have an opening which is as large as that of the draw-in zones of conventional rubber extruders. Since, in the present case, the extruder 2 is fed via the gear pump 1, the cylinder surrounding the screw can be closed such that the feed zone is the only opening in the wall of the cylinder. Since the gear pump 1 can also transport in opposition to

high pressures, substantial pressure levels can already be achieved in the draw-in zone 2E of the device in accordance with the invention.

In order to monitor proper drawing-in of the rubber strips 3S and/or to quickly recognize a possible tearing of the rubber strips 3S, at least one roller 10 is loaded by a weight 9 for monitoring the pressure with which the rubber strip 3S is introduced to the gear pump 1 or with which same is drawn-in thereby.

An apertured plate 11, a sieve package or the like is provided for at the outlet 1A of the gear pump 1 for filtering the rubber 3. In this manner, the rubber 3 is subjected to a large shear force in the gear pump 1 for only a short period of time whereas, in contrast to conventional extruders, the absolute path depths in the gear pump 1 are relatively small so that a homogeneous shearing is effected over the entire cross section of the rubber 3. In this manner the gear pump 1 is capable of building-up relatively high pressures. Since the temperature increase in the gear pump 1 assumes values of approximately 60 to 80°C, the rubber 3 is thereby filtered at a temperature of about 80 to 100°C, departing from a room temperature of 25°C. In practical applications, filtering with the assistance of extruders is unavoidably associated with mass temperatures in the region of 120°C to 150°C. The device in accordance with the invention therefore describes a manner in which the rubber 3 can be filtered at a substantially cooler level. The rubber 3 is, however, also preheated in a homogeneous fashion via the extrusion of the rubber 3 through the apertured plates 11 or through a sieve package.

In the embodiment according to Fig. 2, additional gear pumps 1.1, 1.2, ... 1.n are provided for downstream of gear pump 1. Extruder 2 is located downstream of the last gear pump 1.n. This configuration of the device in accordance with the invention facilitates a larger temperature increase than that achievable with a single gear pump 1. In addition, each gear pump 1.1, 1.2 ... 1.n acts as an attenuator for feed fluctuations so that a flow of rubber 3 having higher regularity can be achieved at the outlet of the last gear pump 1.n. For certain products, e. g. which do not need a high level of devolatilization, the extruder can be eliminated and a die can be fed directly by the gear pump.

Figures 3, 4, and 5 show an extruder 2 having a vacuum lock 12. The feed zone is constructed in such a way as to facilitate a significant pressure build-up (as also described in figure 1). In contrast to the solution of figure 1, the vacuum pump suctions the material at a barrel position behind the vacuum lock 12. Pressure measuring devices 4 measure pressure in the outlet location P(1A), the transfer location P(6), and the cylinder zone P(7) and transfer the corresponding signals P1A, P6, and P7 to regulation device 5 for regulation of the rate of revolution n of the gear pump 1. Since the gear pump produces a substantial pressure (and the feed zone as well), the screw can be of shorter construction than conventional devolatilization extruders.

Figure 4 shows a device, wherein the extruder 2 has no characteristic feed zone whatsoever. The preplasticized material is transported by the gear pump 1 and pressed directly onto a cylindrical coating mandrel 13 disposed in a stationary manner surrounding rotating vacuum lock 12 to

enlarge the surface of the extrudate and distribute it over the circumference of the screw surface of the vacuum lock 12.

Figure 5 shows a device wherein the extruder is provided with a spiral groove 15 in the barrel wall which distributes the material in a manner described in relation to Fig. 4.

Claims

1. A method for plasticizing, filtering, dosing and transporting high viscous polymer melts (3), e. g. of a rubber and/or polymer plastic mixture using a gear pump (1) and an extruder (2)
characterized in that
 - 1.1 the melt (3) is introduced to the gear pump (1) in a non-plasticized form or drawn-in by same;
 - 1.2 plasticizing of the melt (3) is effected during transport via the teeth (1Z) of the gear pump; and
 - 1.3 the melt (3) is then directly transferred to the extruder (2) in a plasticized state.
2. Method according to claim 1, characterized in that a regulation of the rate of revolution of the gear pump (1) is effected during processing in correspondence with the pressure directly present at outlet (1A) of the gear pump (1).
3. Method according to claim 1, characterized in that a regulation of the rate of revolution of the gear pump (1) is effected during processing in correspondence with pressure at the transfer location (6) between the gear pump (1) and the extruder (2).

4. Method according to claim 1, characterized in that a regulation of the rate of revolution of the gear pump (1) is facilitated during processing in correspondence with the pressure in the first cylinder zone (7) following the feed zone.
5. Method according to one of the claims 1 through 4, characterized in that a suctioning-off of volatile components of the melt (3) is effected in the inlet zone (2E) of the extruder (2) via a suction device (8).
6. Method according to one of the claims 1 through 5, characterized in that filtering of the melt (3) is effected at the outlet (1A) of the gear pump (1) via an apertured plate (11) disposed at this location and/or a sieve package.
7. Method according to one of the claims 1 through 6, characterized in that, subsequent to transport through the gear pump (1), the melt (3) is fed through at least one additional gear pump (1.1, 1.2, ... 1.n) and is plasticized therein, and that transfer of the melt (3) to the extruder (2) is effected subsequently thereto.
8. Device for carrying out the method according to one of the claims 1 through 7, characterized in that the extruder (2) is downstream of the gear pump (1).
9. Device according to claim 8, characterized in that a pressure measuring device (4) is located at the outlet (1A) of the gear pump (1) to measure the pressure of the gear pump (1) directly at outlet (1A) during processing and to introduce the measured

values to a regulation device (5) for regulating the rate of revolution of the gear pump (1).

10. Device according to claim 8, characterized in that a pressure measuring device (4) is disposed at the transfer location (6) between the gear pump (1) and the extruder (2) to measure the pressure directly at the transfer location (6) between the gear pump (1) and the extruder (2) during processing and to introduce the measured values to a regulation device (5) for regulating the rate of rotation of the gear pump (1).
11. Device according to claim 8, characterized in that a pressure measuring device (4) is disposed in the first cylinder zone (7) to measure the pressure in the first cylinder zone (7) during processing and to introduce the measured values to a regulation device (5) for regulating the rate of revolution of the gear pump (1).
12. Device according to one of the claim 8 through 11, characterized in that a suction device (8) for suctioning volatile components of the melt (3) is disposed at the draw-in zone (2E) of the extruder (2).
13. Device according to one of the claims 8 through 12, characterized in that the draw-in zone (2E) of the extruder (2) is configured in such a fashion as to facilitate the build-up of high mass pressures.
14. Device according to one of the claims 8 through 13, characterized in that an apertured plate (11) and/or a sieve package is disposed at the outlet (1A) of the

gear pump (1) for filtering the melt (3).

15. Device according to one of the claims 8 through 14, characterized in that at least one additional gear pump (1.1, 1.2 ... 1.n) is disposed at the outlet (1A) of the gear pump (1) and the extruder (2) is disposed downstream the last gear pump (1.n).
16. The device of claim 8, characterized in that the extruder (2) has a vacuum lock (12) and a vacuum pump (8) is disposed to suction the melt (3) at a barrel position downstream of the vacuum lock (12), wherein a substantial amount of pressure needed to overcome the vacuum lock is generated by the gear pump (1).
17. The device of claim 8, characterized in that the extruder (2) has a vacuum lock (12) and a vacuum pump (8) is disposed to suction the melt (3) at a barrel position downstream of the vacuum lock (12), and a cylindrical mandrel is disposed about the vacuum lock (12) for enlarging a surface of an extrudate and for distributing the extrudate over a screw surface of the vacuum lock (12), wherein a substantial amount of pressure needed to overcome the vacuum lock and the cylindrical mandrel is generated by the gear pump (1).
18. The device of claim 8, characterized in that the extruder (2) has a vacuum lock (12) and a vacuum pump (8) is disposed to suction the melt (3) at a barrel position downstream of the vacuum lock (12), wherein an inner wall of the extruder surrounding the vacuum lock (12) has a spiral groove for enlarging a surface of an

extrudate and for distributing the extrudate over a screw surface of the vacuum lock (12).

19. The device of claim 8, characterized in that the extruder (2) has a vacuum lock (12) and a vacuum pump (8) is disposed to suction the melt (3) at a barrel position downstream of the vacuum lock (12), wherein the inner wall of the extruder surrounding the vacuum lock (12) has a spiral groove for enlarging a surface of an extrudate and for distributing the extrudate over the screw surface of the vacuum lock (12) and a substantial amount of pressure needed to overcome the vacuum lock (12) and the spiral groove is generated by the gear pump (1).

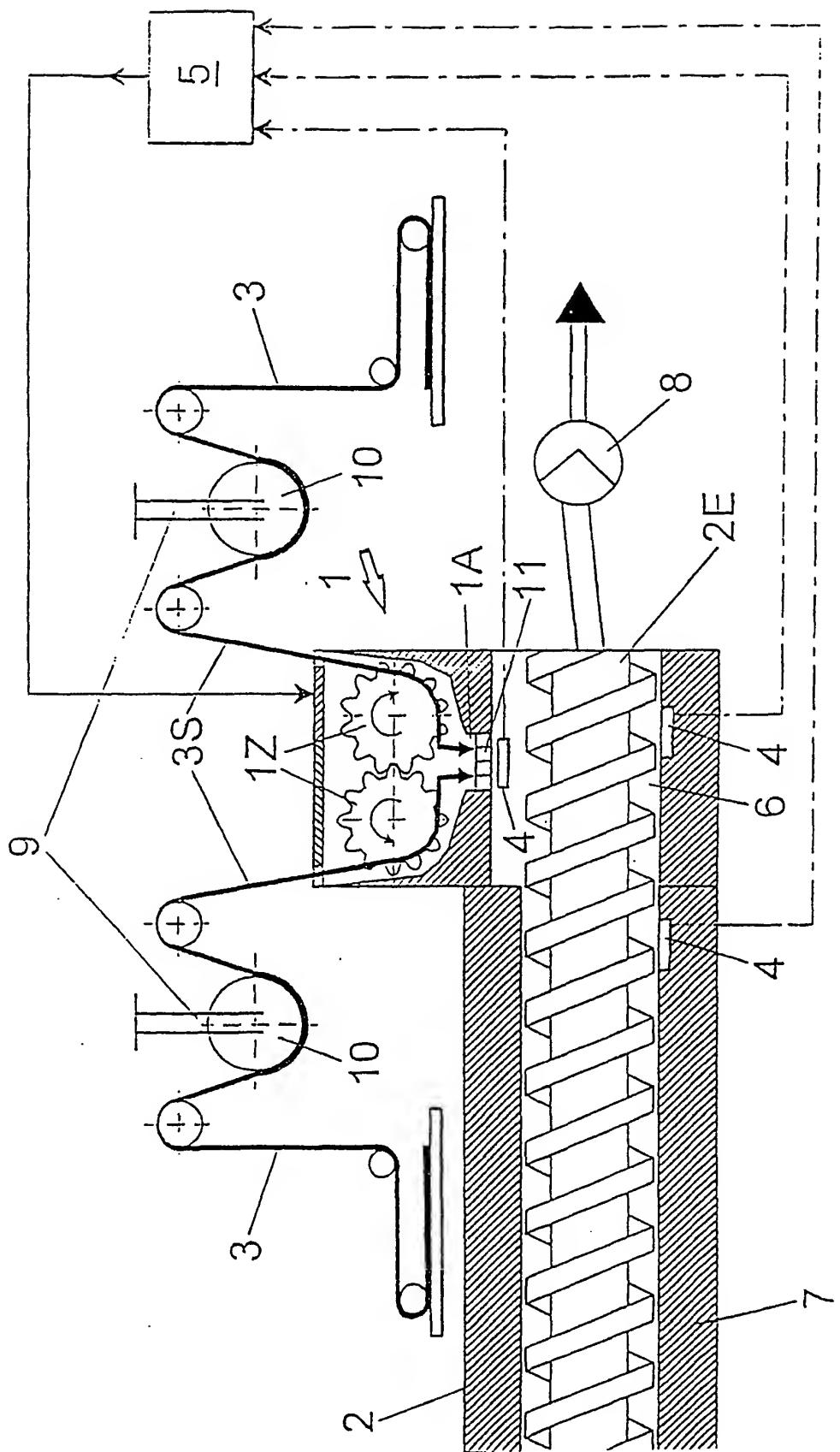


Fig. 1

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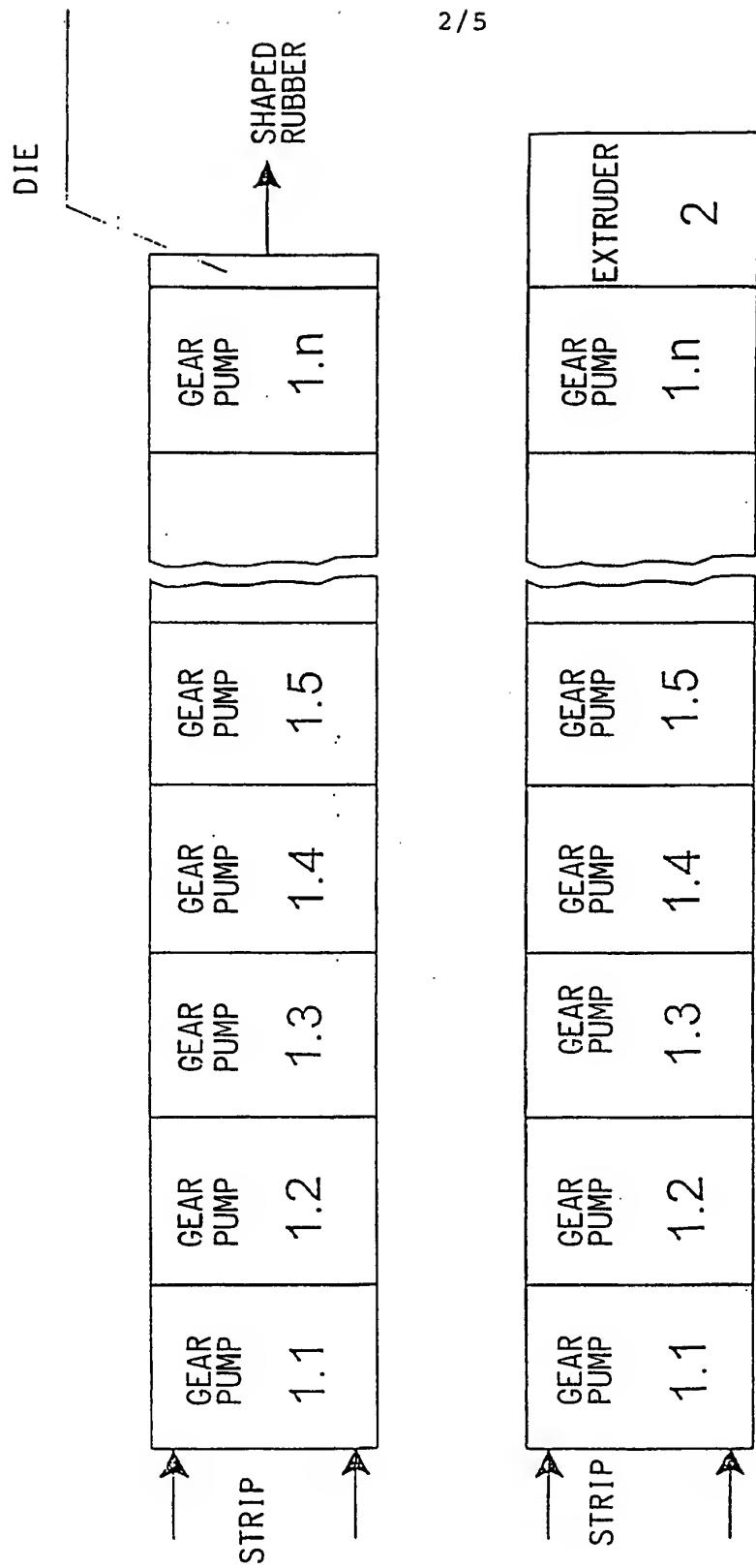
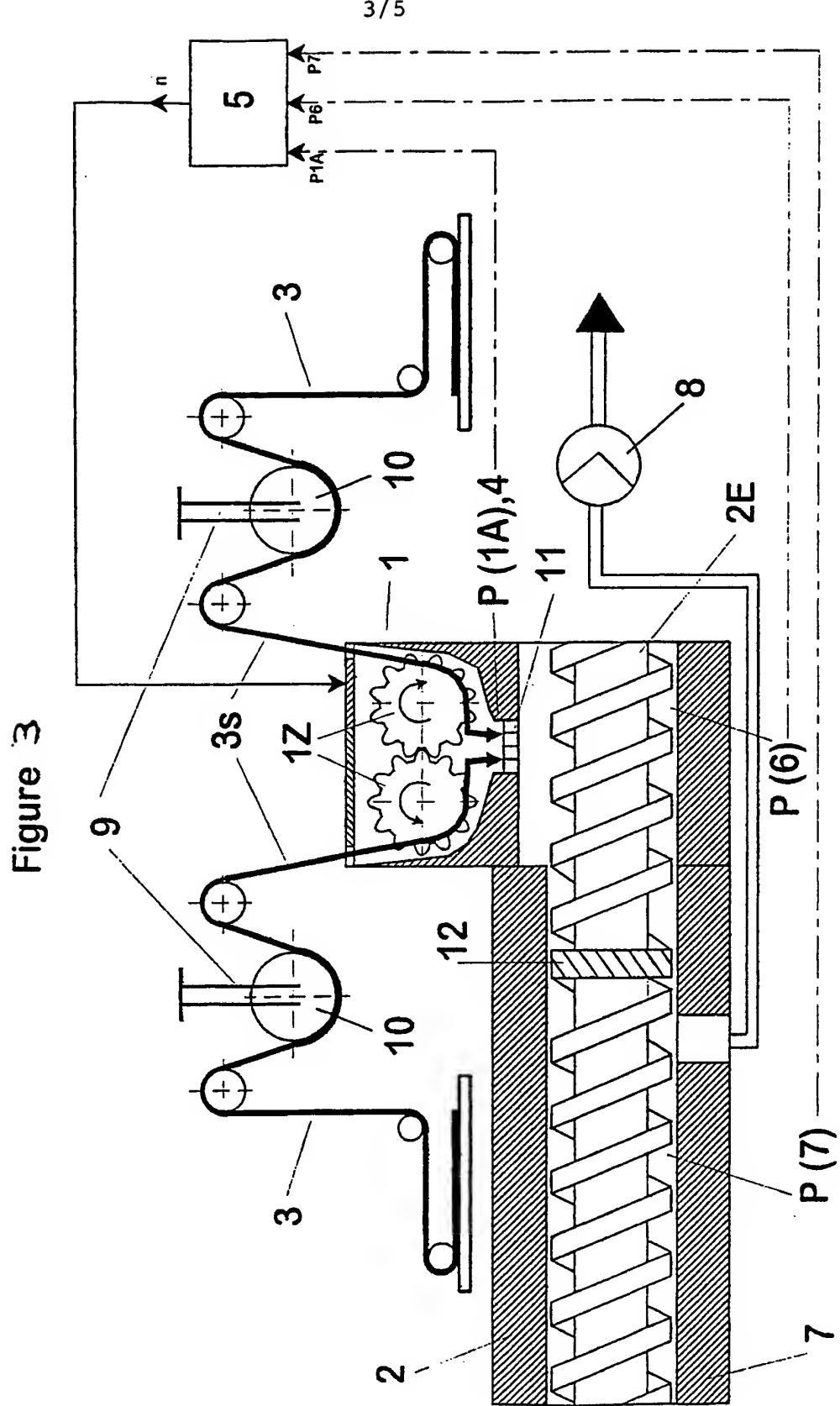


Fig. 2

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Figure 4

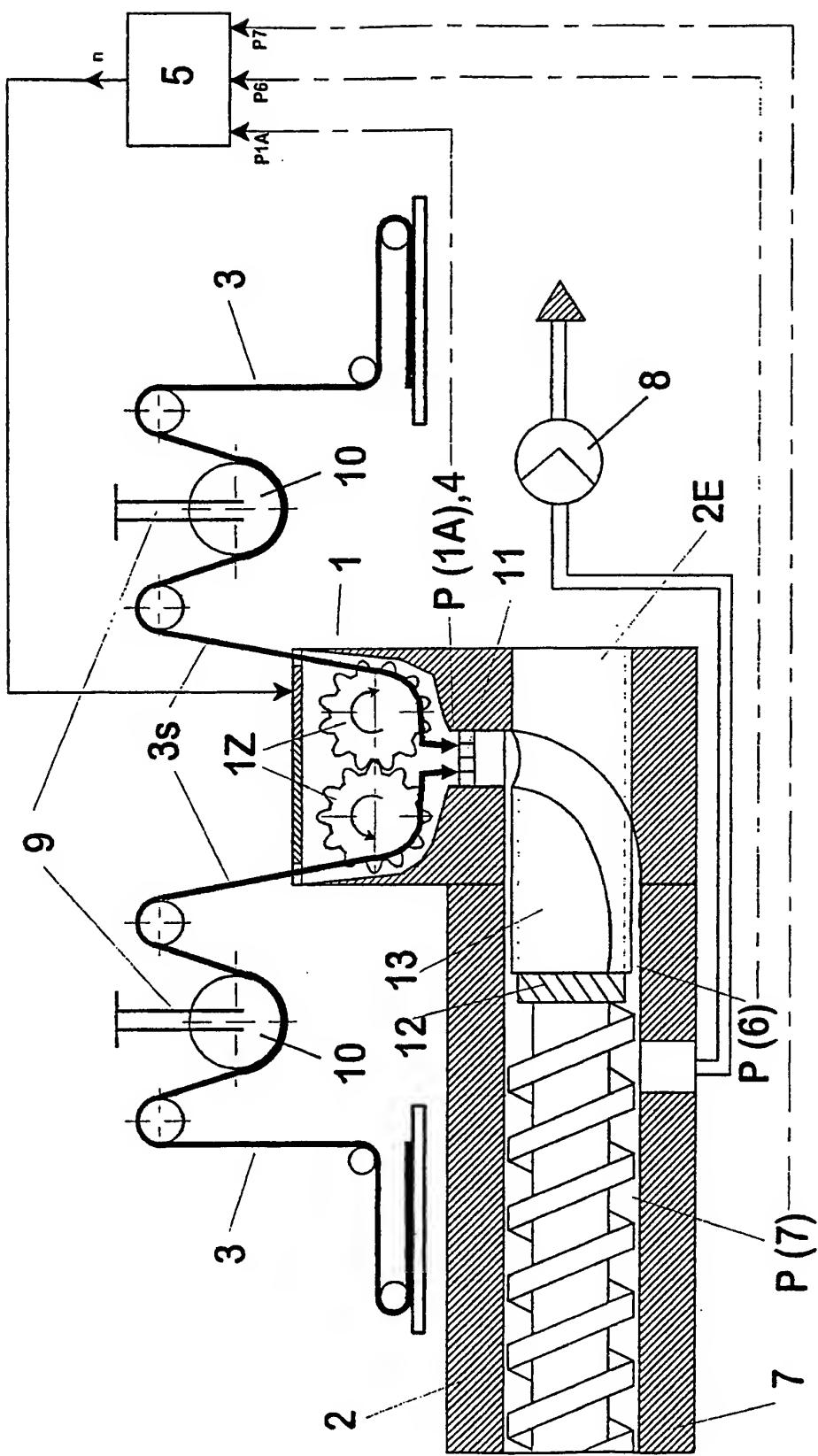
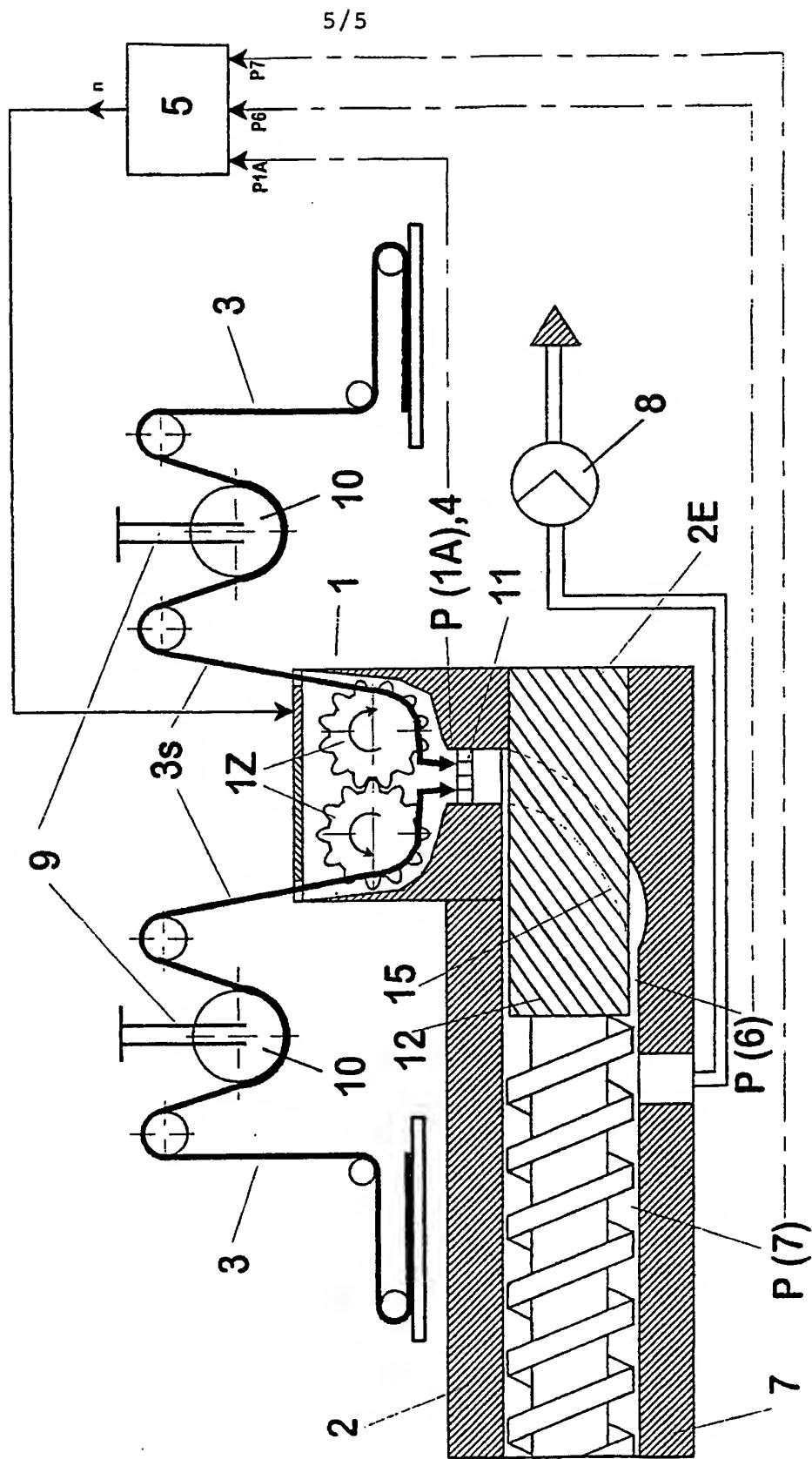


Figure 5



A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B29C47/50 B29C47/10 B29C47/76

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 1 466 689 A (BARMER MASCHINENFABRIK AKTIENGESELLSCHAFT) 7 April 1967 see page 2, left-hand column, line 52 - right-hand column, line 36 ---	1-19
A	EP 0 470 510 A (KRAUSS MAFFEI AG) 12 February 1992 see column 1, line 55 - column 2, line 25 see column 2, line 40 - column 3, line 15 see claims; figures 1-4 ---	1-19
A	US 4 537 568 A (LARSSON GOESTA) 27 August 1985 see the whole document ---	1,8
A	DE 32 33 416 A (KALWAR KLAUS) 3 May 1984 see page 13, line 4 - page 14, line 7 see figure 3 -----	



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Date of the actual completion of the international search

22 January 1998

Date of mailing of the international search report

28/01/1998

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